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EIA STANDARD

EIA-708-B

Digital Television (DTV) Closed Captioning

EIA-708-B

(Revision of EIA-708-A)

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FOREWORD

This document specifies the standards for Closed Captioning in Digital Television (DTV) technology. This standard was developed under the auspices of the Consumer Electronics Association (CEA, formerly CEMA) Technology & Standards R4.3 Television Data Systems Subcommittee in parallel with the U.S. Advanced Television Systems Committee's (ATSC) and the Advanced Television Grand Alliance's definition, design, and development of the audio, video and ancillary data processing standard for Advanced Television. The DTV standard developed by the Grand Alliance and other industry members is represented in ATSC A/53, and the informative document, ATSC A/54.

Users of this standard should note that, at some future point, it is expected that provisions necessary to accommodate NTSC line 21 data transmission will be established.

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DIGITAL TELEVISION (DTV) CLOSED CAPTIONING

1 Scope

This document is intended as a definition of DTV Closed Captioning (DTVCC) and provides specifications and guidelines for caption service providers, DTVCC decoder and encoder manufacturers, DTV receiver manufacturers, and DTV signal processing equipment manufacturers. This specification includes the following:

- a description of the transport method of DTVCC data in the DTV signal
- a description of DTVCC specific data packets and structures
- a specification of how DTVCC information is to be processed
- a list of minimum implementation recommendations for DTVCC receiver manufacturers
- a set of recommended practices for DTV encoder and decoder manufacturers

The use of the term "DTV" (Digital Television) throughout is intended to include, and apply to, HDTV (High Definition Digital Television) and SDTV (Standard Digital Television) which use the digital data stream specified in ATSC A/53 and related ATSC A/54.

1.1 Overview

DTV Closed Captioning is a migration of the closed-captioning concepts and capabilities developed in the 1970's for NTSC television video signals to the high-definition television environment defined by the ATV (Advanced Television) Grand Alliance and standardized by the Advanced Television Systems Committee (ATSC). This new television environment provides for larger screens and higher screen resolutions, and higher data rates for transmission of closed-captioning data.

NTSC Closed Captioning consists of an analog waveform inserted into Line 21 of the NTSC Vertical Blanking Interval (VBI). This waveform provides a transport channel which can deliver 2 bytes of data on every field of video. This translates to 120 bytes per second (Bps), or 960 bits per second (bps). In contrast, DTV Closed Captioning is transported as a logical data channel in the DTV digital bit stream. Of the DTV bitstream bit rate (which is 19.4 Mbps for terrestrial broadcast, and 38.4 Mbps for cable), DTV-specific closed captioning is allocated 9600 bps. This increased capacity opens the possibilities for the simultaneous transmission of captions in multiple languages and at multiple reading levels.

The DTV standard accommodates a variety of increased vertical and horizontal screen resolutions (e.g., 480 x 704, 720 x 1280 and 1080 x 1920), versus the single 525 vertical scan line format for NTSC. These added resolutions provide for more defined representations of character fonts and other on-screen objects.

The heart of DTVCC caption display is the caption "window" which is identical to the *window* concept found in all computer Graphical User Interfaces (GUI). Windows are placed within the DTV screen, and caption text is placed within windows. Windows and text have a variety of color, size and other attributes.

This document describes the above issues in a reverse-hierarchical (i.e., low-to-high level) fashion. It follows an "Open Systems Interconnect (OSI) Reference Model"-type protocol stack for layered protocols. DTVCC consists of 5 protocol layers: the Transport Layer, the Packet Layer, the Service Layer, the Coding Layer, and the Interpretation Layer. The discussion of the first 3 layers is a detailed presentation of data transport and organization issues. The discussion of the last 2 layers provides a more informative presentation of the unique aspects of closed captioning. Some readers may wish to start with these last 2 layers first, beginning in section 7.

Throughout EIA-708-B, in concert with ATSC A/53, the lowest numbered bit in a multibit numbered value is considered to be least significant (uimsbf).

2 Normative References

The following references contain provisions, which, through reference in this text, constitute normative provisions of this standard. At the time of publication, the edition indicated was valid. All standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent edition of the standard indicated below.

2.1 Normative Reference List

ANSI X3.4, Information Systems - Coded Character Sets - 7-bit American National Standard Code (1986 (R1997))

ANSI X3.41, Code Extension Techniques for Use with the 7-Byte Coded Character Set of ASCII (1990)

ATSC A/53, ATSC Digital Television Standard (1995)

ATSC A/65, Program and System Information Protocol for Terrestrial Broadcast and Cable (1997)

EIA-608-A, Line 21 Data Service (1999)

ISO/IEC 2022, Information technology - Character code structure and extension techniques (1994)

ISO/IEC 8859-1, Information technology - 8-bit single-byte coded graphic character sets - Part 1: Latin alphabet No. 1 (1998)

ISO/IEC 13818-1, Information technology - Generic coding of moving pictures and associated audio information: Systems (1997)

SMPTE Standard 12M, Television, Audio and File – Time and Control Code (1999)

TIA/EIA-574, 9 Position Non-Synchronous Interface between Data Terminal Equipment and Data Circuit-Terminating Equipment Employing Serial Binary Data Interchange (1998)

2.2 Normative Reference Acquisition

ANSI or EIA or TIA/EIA Standards:

- Global Engineering Documents, World Headquarters, 15 Inverness Way East, Englewood, CO USA 80112-5776; Phone 800-854-7179; Fax 303-397-2740; Internet http://global.ihs.com; Email global@ihs.com

ATSC Standards:

- Advanced Television Systems Committee (ATSC), 1750 K Street N.W., Suite 1200, Washington, DC 20006; Phone 202-828-3130; Fax 202-828-3131; Internet http://www.atsc.org/stan&rps.html

ISO/IEC Standards:

- Global Engineering Documents, World Headquarters, 15 Inverness Way East, Englewood, CO USA 80112-5776; Phone 800-854-7179; Fax 303-397-2740; Internet http://global.ihs.com; Email global@ihs.com
- IEC Central Office, 3, rue de Varembe, PO Box 131, CH-1211 Geneva 20, Switzerland; Phone +41 22 919 02 11; Fax +41 22 919 03 00; Internet http://www.iec.ch; Email pubinfor@iec.ch
- ISO Central Secretariat, 1, rue de Varembe, Case postale 56, CH-1211 Geneve 20, Switzerland; Phone +41 22 749 01 11; Fax +41 22 749 01 55; Internet http://www.iso.ch; Email mbinfo@iso.ch

SMPTE Standards:

- Society of Motion Picture & Television Engineers, 595 W. Hartsdale Ave., White Plains, NY 10607-1824 USA Phone: 914-761-1100 Fax: 914-761-3115, Email: eng@smpte.org; Web: http://www.smpte.org

3 Caption Channel Layered Protocol

A formal data communications channel protocol has been established for the DTVCC caption data channel. This formalization provides a framework for describing the caption communications hierarchy. Grouping the structures, concepts, and features of this environment into the following hierarchical layers aids in the understanding of the organizational aspects of the DTVCC system.

There are 5 layers in the Caption Channel data framework: Transport Layer, Packet Layer, Service Layer, Coding Layer, and Interpretation Layer (see Figure 1). These layers map to the top-most layers of the OSI Reference Model as shown in Table 1.

OSI Protocol Reference Model	DTVCC Protocol Model
Application	Interpretation Layer
Presentation	Coding Layer
Session	Service Layer
-	Packet Layer
Transport	Transport Layer
Network	-
Link	-
Physical	-

Table 1 DTVCC Protocol Stack

The DTVCC Transport Layer maps to the OSI Transport Layer. This layer marks where DTVCC data leave the DTV Video subsystem and are introduced to the DTV Closed-Caption decoder in the receiving equipment. Within the DTVCC decoder, DTVCC data are further processed up through the remaining layers of the DTVCC Protocol Model.

The DTVCC Packet Layer marks where DTVCC data enter the DTVCC decoder. This is a protocol data reassembly layer which buffers incremental bitstream data into a byte-aligned, multi-byte packet. There is no specific counterpart in the OSI model for this layer.

Processing of the Caption Channel packet data begins in the DTVCC Service Layer. Caption Channel packets are broken up into the encapsulated sub-blocks of data to be routed to the separate caption service processing routines within the decoder. Services define separate caption data streams. TV viewers may choose to view the processed data for one or more services at a time. For example, a caption channel may contain an English language service and a Spanish language service.

The DTVCC Coding Layer breaks out the individual caption commands and caption text sequences from the service data blocks. The DTVCC Coding Layer maps to the OSI Presentation Layer.

The Interpretation Layer processes the caption elements presented by the DTVCC Coding Layer. The Interpretation Layer maps to the OSI Application Layer.

This layered framework for DTVCC is further detailed in the remaining sections of EIA-708-B.

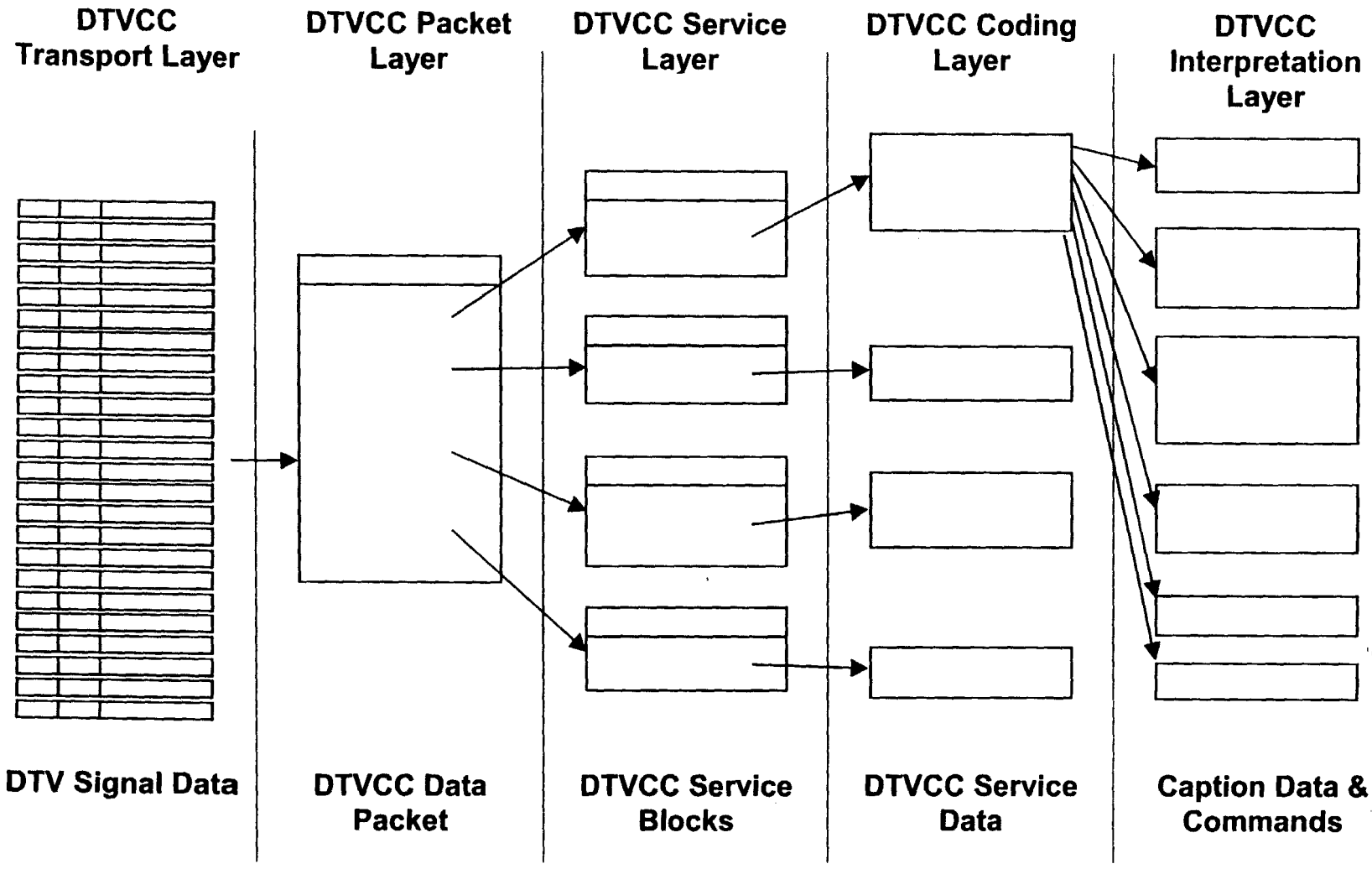

Figure 1 DTV Closed-Captioning Protocol Model

4 DTVCC Transport Layer

The transport of the Caption Channel is defined in ATSC A/53 and ISO/IEC 13818. The DTVCC Transport Layer consists of the mechanisms for transporting caption data from the encoder at the caption-encoding head-end to the decoding hardware in the TV receiver. DTVCC related data, when present, is transported in three separate portions of the DTV stream: the Picture User Data, the Program Mapping Table (PMT) and the Event Information Table (EIT). DTVCC Service Data (caption text, window commands, etc) are carried as MPEG-2 Picture User Data, and the DTVCC Caption Channel Service Directory is carried as descriptor information in the PMT and, when present, the EIT.

The DTV video bitstream, the PMT and the EIT are multiplexed with the other audio, data, control and synchronization bit streams comprising the DTV system signal as depicted in Figure 2.

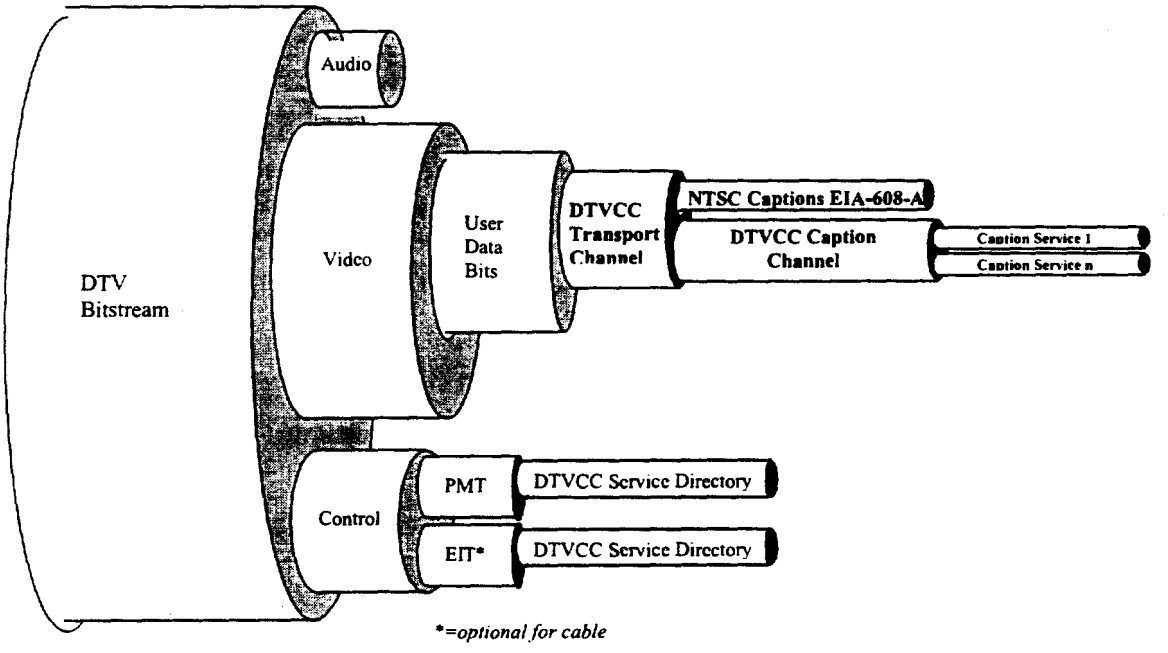

Figure 2 DTVCC Caption Data in the DTV Bitstream

4.1 9,600 Bits Per Second DTVCC Transport Channel

The DTVCC design allows for caption data to be transmitted at various data rates within a DTV signal or any similar MPEG-2 variation. However, for DTV and DTVCC specific (i.e., ATSC A/53) caption encoding, the DTV Closed-Captioning channel is a continuous 9600 bps stream allocated from the DTV signal capacity. In order to provide this continuous stream and to ensure that specific caption data will reach receivers as intended (in relationship to the audio and video), this data channel is allocated on a frame-by-frame basis such that 1200 bytes of data are transported per second. For example, for an interleaved DTV video signal with a 60 Hz frame rate, 20 bytes of DTVCC caption channel data are allocated in each frame.

It is very important to note that the allocation for NTSC closed-caption encoding within the DTVCC Transport Channel (i.e., Picture User Data) is included in the DTVCC Caption Channel bandwidth. That is, the total DTVCC Transport Channel (consisting of the DTVCC Caption Channel and the NTSC Caption Channel) within the Picture User Data is 9600 bps. On average, NTSC (EIA-608-A) captions are allocated 960 bps, and DTVCC captions (EIA-708-B) are allocated 8640 bps.

4.2 Pre-Allocated Bandwidth

The DTVCC Transport Channel is a fixed, pre-allocated stream which exists in all DTV-system bit streams, even though captions may not be present. This ever-present bandwidth (which includes NTSC and DTVCC caption data) allows encoders to easily insert caption data into the DTV bit-stream at the point of origin and at multiple down-stream encoding points without having to perform complex picture data processing and bandwidth re-allocation. In addition, it allows for easier decoding of the closed-caption data by the receiver since the data will always be at known locations.

4.3 NTSC Caption Data

The consideration for NTSC captioning (EIA-608-A) exists to facilitate the transcoding of the DTV video to NTSC video, and to preserve all line 21 data during the transcode process. The NTSC closed-captioning allocation is detailed further in this section. Section 9.23 provides a further discussion of the transcoding issue.

The NTSC closed caption data bytes are not embedded within the DTV closed-caption protocol stack. That is, they are not passed onto the DTVCC Packet Layer; rather, they are extracted at the Transport Layer and routed to a separate NTSC caption decoder (if present). This allows for simpler closed-caption decoder implementations (e.g., DTV-to-NTSC settop transcoders) since the entire DTVCC Caption Channel data stream does not have to be parsed to find a few bytes of NTSC data.

This is especially true for devices (e.g., set-top boxes) which are to convert DTV signals into NTSC to accommodate NTSC television receivers. These devices ignore the DTVCC closed-caption data in the DTV Picture User Data bits and transcode the NTSC closed-caption data into the NTSC Line-21 data stream. This allows for easier insertion of NTSC closed-caption data by the encoder since the NTSC data bytes do not have to be buried within the DTVCC Coding Layer.

4.4 DTV/MPEG-2 Picture User Data (User Bits)

While Video User Bits may be inserted at any of three levels (i.e., Sequence level, the Group of Pictures (GOP) level, and the Picture Data level) within the video bitstream sequence, ATSC A/53 specifies that the DTVCC Transport Channel is only encoded at the Picture Data level (i.e., user data level 2).

The following is a technical discussion of the DTV Picture User Data format. This discussion is intended for the technical audience, such as encoder and decoder manufacturers. The bitstream description syntax convention used in the two referenced documents is also used here to describe the DTV user data. Please refer to these documents for a normative explanation of this syntax.

4.4.1 Picture User Data Bitstream Construct

The extension_and_user_data(2) and user_data() constructs defined in ATSC A/53 carry the DTVCC data within the MPEG Video Picture User Data Level. This section augments the definition of the *cc_type* and *cc_valid* elements in the user_data(2) construct.

cc_valid - This flag indicates whether the following two closed-caption data bytes are valid. If *cc_valid* = 1, then the following two bytes of closed-caption data are valid. Otherwise, the two closed caption bytes are invalid (i.e., null

filled). For NTSC Line 21, Field 1 and Field 2 captions, if *cc_valid* = 0 then the run-in clock and start bit should not be generated for the NTSC data stream when transcoding from DTV to NTSC.

cc_type - Denotes the type of the following two bytes of closed caption data as indicated in Table 2.

cc_type	Contents
00	NTSC line 21 field 1 closed captions
01	NTSC line 21 field 2 closed captions
10	DTVCC Channel Packet Data
11	DTVCC Channel Packet Start

Table 2 Closed-Caption Type (cc_type) Coding

DTV Closed-Caption data is transmitted (encoded) in variable-rate, variable-sized DTVCC Caption Channel Packets (see Section 5). To allow for simple extraction and insertion of these packets without the need to fully parse their contents, the first byte-pair of each DTVCC Caption Channel Packet shall be marked using the *cc_type* = 11 syntax flag (i.e., DTVCC Caption Channel Packet Start). The remaining byte-pairs of the DTVCC packet shall be marked with the *cc_type* = 10 flag (i.e., DTVCC Caption Channel Packet Data).

A DTVCC Caption Channel Packet may continue from one picture user_data extension to the next. The end of the packet is indicated by either: (1) receipt of the header (*cc_valid* = 1, *cc_type* = 11) of the next DTVCC packet, or (2) receipt of a byte-pair where *cc_valid* = 0 and *cc_type* = 10 or *cc_type* = 11.

> NOTE--In the DTV video compression standard, coded pictures are transmitted in a different order ("Transport" order) than they are displayed ("Display" order). Since the DTVCC captioning data extensions are part of the video coded picture constructs and follow the MPEG Video coded-picture reordering process, the order in which the captioning data extensions are transmitted is not the same order in which they will be processed by the DTVCC Decoder. The captioning data extensions must be reordered (by the "MPEG Video Decoder") along with the pictures to which they correspond prior to the DTVCC Caption Channel Packet location and extraction method described previously. Once these captioning data are reordered, they will be ready for processing by the DTVCC Decoder.

4.4.2 Frame Rates

As stated above, the value of *cc_count* will vary depending on the frame rate. In any given video service, the frame rate may change (e.g, to "film-mode" during extended still picture periods). The *user_data()* construct shall be transmitted a number of times per second, and *cc_count* shall be adjusted for each such construct so that the 9600 bps DTV Transport Channel throughput is sustained no matter what the instantaneous frame rate is.

The frame rate for a DTV video stream is dependent upon a combination of the values for the following MPEG-2 parameters (i.e., video bitstream elements): *frame_rate_code, progressive_sequence, top_field_first, repeat_first_field* and *picture_structure*. These parameters are defined in ISO/IEC 13818. When defining the frame rate, these parameters also govern the *user_data()* construct transmit rate and the value of *cc_count*.

Table 3 shows the values derived for the *user_data(2)* transmit rate, and the *cc_count* values per each frame such that the DTVCC Transport Channel data rate of 9,600 bps is maintained.

Table 3 also shows the relationship between the number of DTV data bytes vs. NTSC bytes contained in the DTVCC user data.

NTSC captioning information shall not exceed the data rate of an NTSC display (30/1.001 * 2 bytes per second). The number of cc_count of each NTSC cc_type shall be no greater than 30 /1.001 per second while the stream is active. This data rate may be maintained by averaging the number of each cc_type over up to 1 001/30 seconds.

This requirement must be met across splices. For example, when two sequences with frame_rate_value of either 30 or 60 are spliced, the splicer could delete NTSC caption information from either the 1/30 second of the ending sequence or the first 1/30 second of the new sequence.

NTSC captioning information should maintain the order of an NTSC display. If both cc_type 00 and cc_type 01 data are present in the picture user data constructs of a sequence, they should alternate when the pictures are restored to display order.

For video sequences with progressive_sequence ==0 for pictures with top_field_first==0, cc_type 00 shall precede cc_type 01.

For video sequences with progressive_sequence ==0 for pictures with top_field_first==1, cc_type 01 shall precede cc_type 00.

For picture_structure of Top Field, cc_type 00 shall not be present.

For picture_structure of Bottom Field, cc_type 01 shall not be present.

For video sequences with progressive_sequence == 1, the ordering of cc_type 00 and cc_type 01 is arbitrary. Either 4 or 6 NTSC *cc_data_*bytes may be included in each *user_data*() structure, subject to the data rate restriction above. DTV *cc_data_*bytes may also be present to produce a total data rate of 9120 bps, subject to the constraint on *cc_count*.

When the picture display time is extended from the nominal value of frame_rate stated in the video sequence header through the repeat mechanisms in the picture_coding_extension, the values of cc_count and number of NTSC cc_data_bytes in user_data() shall be modified. Values for cc_count and cc_data_bytes are shown in Table 3.

Frame_rate_value	**picture_structure**	**progressive_frame**	**repeat_first_field**	**top_field_first**	**cc_count**	**NTSC cc_data_bytes**	**DTV cc_data_bytes**
60 or 59.94	11	1	0	0	10	2	18
60 or 59.94	11	1	1	0	20	4	36
60 or 59.94	11	1	1	1	30	6	54
30 or 29.97	01 or 10	0	0	0	10	2	18
30 or 29.97	11	x	0	x	20	4	36
30 or 29.97 (note)	11	1	1	x	30	6	54
24 or 23.97	11	1	0 (required)	0 (required)	25	4 or 6	44 or 46
(x = may be 0 or 1) Note: For sequences with frame_rate_value = 30, or 29.97, progressive_frame ==1 and repeat_first_field==1 implies progressive_sequence==0.							

Table 3 DTVCC Transport Channel Transmit Rate Parameters

For ease of inserting and retrieving the NTSC closed captions, NTSC Line 21, Field 1 and Field 2 captions must always be placed in the User Data stream before any DTVCC caption data. The NTSC closed-caption data order (Field 1 vs. Field 2) will depend on the field display order. With this scheme, once the decoder sees *cc_type* = 10 or *cc_type* = 11, indicating DTVCC caption data, it will no longer continue searching the User Data for NTSC captions. All NTSC closed-caption data will follow the format and protocol as specified in EIA-608-A.

In the case of a 60 Hz frame rate, 2 bytes of NTSC captions are allocated per user_data extension. Two (2) bytes of Field 1 NTSC captions are to be encoded every other frame, with 2 bytes of Field 2 NTSC captions encoded in the intervening frames. In all other cases (i.e., lower frame rates), Field 1 and Field 2 captions exist within the same user_data extension.

4.4.3 Typical Video Signals

Table 4 illustrates an example of the arrangement of the closed-caption data stream in the Picture User Data for a typical 30 frames per second video signal frame where *cc_count* = 20. A Caption Channel Packet starts immediately after the NTSC caption data.

	Marker_bits	cc_valid	cc_type	cc_data1	cc_data2
1	1111 1	1	00	NTSC Line 21 field 1	NTSC Line 21 field 1
2	1111 1	1	01	NTSC Line 21 field 2	NTSC Line 21 field 2
3	1111 1	1	11	byte #1: DTVCC Pkt Header	byte #2: DTVCC Pkt Data
4	1111 1	1	10	byte #3: DTVCC Pkt Data	byte #4: DTVCC Pkt Data
•	•	•	•	•	•
•	•	•	•	•	•
•	•	•	•	•	•
20	1111 1	1	10	byte #35: DTVCC Pkt Data	byte #36: DTVCC Pkt Data

Table 4 Aligned User Data and DTVCC Channel Packet Example

Table 5 shows the User Data frame encoding of unaligned Caption Channel Packets. The end of a previous Caption Channel Packet (that was 128 bytes in length) is in the first 4 bytes of the User Data after the NTSC caption data. The start of the first 32 bytes of a new Caption Channel Packet fills the remainder of the 40 bytes of the User Data for a 30 frames per second video signal.

	Marker_bits	cc_valid	cc_type	cc_data1	cc_data2
1	1111 1	1	00	NTSC Line 21 field 1	NTSC Line 21 field 1
2	1111 1	1	01	NTSC Line 21 field 2	NTSC Line 21 field 2
3	1111 1	1	10	byte #125: DTV Pkt Data	byte #126: DTV Pkt Data
4	1111 1	1	10	byte #127: DTV Pkt Data	byte #128: DTV Pkt Data
5	1111 1	1	11	byte #1: DTVCC Pkt Header	byte #2: DTVCC Pkt Data
6	1111 1	1	10	byte #3: DTVCC Pkt Data	byte #4: DTVCC Pkt Data
7	1111 1	1	10	byte #5: DTVCC Pkt Data	byte #6: DTVCC Pkt Data
8	1111 1	1	10	byte #7: DTVCC Pkt Data	byte #8: DTVCC Pkt Data
•	•	•	•	•	•
•	•	•	•	•	•
•	•	•	•	•	•
20	1111 1	1	10	byte #31: DTVCC Pkt Data	byte #32: DTVCC Pkt Data

Table 5 Unaligned User Data and DTVCC Channel Packet Example

The *marker_bits*, *cc_type* and *cc_valid* fields DO NOT use any part of the 9,600 bps bandwidth allocated for closed-caption data. Therefore, 9,600 bps will be maintained for the transport of closed-caption information, including NTSC and DTVCC captions, within the DTV stream.

4.4.4 Latency

As previously discussed in Section 4.4.1, the DTV picture data are transmitted in "Transport Order". This transmission path has an inherent latency associated with it, in that there can be a significant delay from the time the picture data enter a DTV encoder to the time these same data exit a DTV decoder and are available for display processing. The DTVCC data experience this same delay since they are transmitted within the Picture User Data bits, even though the actual DTVCC data are introduced to the encoder in "Display Order', as is the video. ATSC A/53 specifies that this latency may not exceed 0.5 seconds.

This requirement imposes a constraint on the *vbv_delay* parameter of the MPEG-2 Picture Header bitstream construct. This value is the Video Buffering Verifier (VBV) Delay. The VBV is a hypothetical decoder that is

conceptually connected to the output of the DTV encoder. Its purpose is to provide a constraint on the variability of the data that an encoder or editing process may produce.

vbv_delay is a 16-bit unsigned integer in the Picture Header. For constant bit rate operation, *vbv_delay* is used to set the initial occupancy of the decoder's video buffer at the start of play so that the decoder's buffer does not overflow or underflow. *vbv_delay* measures the time needed to fill the VBV buffer from an initially empty state at the target bit rate, R, to the correct level immediately before the current picture is removed from the buffer.

The value of *vbv_delay* is the number of periods of the 90 kHz system clock that the VBV shall wait after receiving the final byte of the picture start code. For a 0.5 second delay, the *vbv_delay* value is 45,000 (i.e., 45,000 cycles / 90,000 cycles per second = 0.5 seconds). If *vbv_delay* <= 45,000 for a picture start code, it means that the closed captions in that picture data will experience a delay of less than 0.5 second in the decoder buffer.

4.5 Caption Channel Service Directory in the PMT and EIT

The Caption Channel Service Directory describes the types and attributes of the Caption Services (see Section 6) encoded in the Picture User Data bits. The Caption Channel Service Directory is contained in the caption_service_descriptor().The caption_service_descriptor() is defined by ATSC A/65, and is carried in the PMT and, when present, the EIT of the MPEG-2 transport stream. Reference ATSC A/65 for a complete description of the caption_service_descriptor.

4.5.1 PMT and EIT Constraints

The following constraints shall be placed on the use of the caption service descriptor:

1) One caption service descriptor shall be present in the PMT and, when present, the EIT to describe each caption service present within the video Picture User Data.
2) There shall be no more than 16 simultaneous caption services present.

4.5.2 PMT Bandwidth Requirements

For the case where the PMT is repeated at the minimum rate of once per 400 msec, the bandwidth needed to deliver a full set of 16 caption service descriptions is 1.98 kbps (i.e.,3 bytes overhead + (6 bytes/description * 16 descriptions) = 99 bytes. 99*8=792 bits. 792 * 2.5 reps/second = 1980 bps). Packetization overhead is not included in this rate.

4.5.3 EIT Bandwidth Requirements

According to ATSC A/65, the recommended cycle time for the currently applicable EIT is 500 msec. Using the same assumptions as the previous paragraph (full set of services for a total of 99 bytes), the bandwidth required is 1.584 kbps.

4.5.4 Decoder Processing of the PMT, EIT and User Data

Even though the Caption Service Descriptors are encoded in the PMT and, when present, the EIT, the decoder only needs to acquire this information from one location. For terrestrial broadcasts, decoders may acquire service descriptors from the EIT only. The EIT carries all relevant event information for a particular program (program titles, duration, ratings, caption directory, etc.). Acquiring all program information from a single, concise table facilitates fast tuning.

In other transmission environments, it may be preferable to use the PMT for acquisition of the Caption Service Descriptor. See Annex A (informative).

5 DTVCC Packet Layer

The DTVCC Caption Channel data within the DTVCC Transport Channel are framed within data "packets" prior to encoding. The DTVCC Caption Channel Packet is totally defined within EIA-708-B. Error correction, error detection, compression, and other low-level transport overhead issues are handled in the transmission DTV layers, and thus fall into the purview of the ATSC and MPEG-2 standards.

The DTVCC Packet Layer is defined by a Caption Channel Packet of **n** bytes of closed captioning data, where **n** <= 128 and **n** is an even number. Packets are coded in the user_data extensions of the coded pictures in the DTV stream. The beginning and ending of each DTVCC packet in the User Data is indicated in the syntax defined in Section4.4.1.

The Caption Channel Packet consists of a 1 byte header and **n**-1 bytes of packet data, where **n** is the total packet size. See Figure 3. The Caption Channel Packet Header contains the packet_size code and a sequence_number. The packet_size_code is in the lower 6 bits (b0 - b5) of the header; its value is "0" when the packet size (**n**) is 128 bytes and "**n**/2" when the packet size is less than or equal to 126 bytes.

Sequence_number is a 2-bit (b6 - b7) rolling sequence number (0 - 3) which is used by receivers to determine lost Caption Channel Packets. When a lost packet is detected,any partially accumulated data from the previously received packet is to be discarded, and the processing associated with the Reset comand shuld be performed for each existing service. See section 8.9.5. Decoding shall resume with the first Service Block encountered in the new packet.

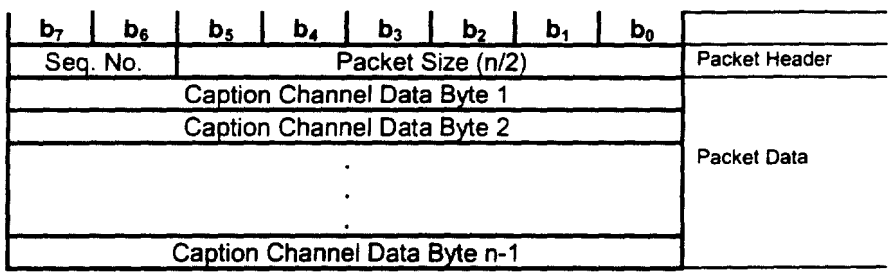

Figure 3 Caption Channel Packet

The syntax for the caption_channel_packet is shown in Figure 4.

```
caption_channel_packet {
        /* packet header  */
        sequence_number: 2 bits
        packet_size: 6 bits


        /* packet data sequence */
        /*if (packet_size_code == 0)*/
                /*packet_data_size = 127 */
        /*else*/
                /*packet_data_size = (packet_size_code * 2) –1 */
        for (i = 0; i < packet_data_size; i++)
        {
                Packet_data[i]     : 8 bits;
        }
}
```

Figure 4 Caption Channel Packet Syntax

6 Caption Service Layer

The DTVCC Caption Channel is divided into a set of logical sub-channels; i.e., "services". Service data are inserted in the Caption Channel when required and where it fits in the caption channel data stream (i.e., Time Division Multiplexed).

The Service Layer defines the headers for the caption data channel service numbers, service types, and service attributes. Receivers use the information in this layer to route the caption packets to the appropriate internal processing modules.

6.1 Services

Caption Channel services are virtual sub-channels in the Caption Channel stream. There are 6 standard services and up to 57 additional extended services allowing for 63 total services.

Service #1 is designated as the Primary Caption Service. This service contains the verbatim, or near-verbatim captions for the primary language being spoken in the accompanying program audio.

Service #2 is designated as the Secondary Language Service. This service contains captions in a secondary language which are translations of the captions in the Primary Caption Service.

The other service sub-channels are not pre-assigned. It is up to the discretion of the individual caption provider to utilize the remaining service channels.

6.2 Caption Channel Service Blocks

Caption Channel Service Blocks provide the structures for the asynchronous time division multiplexing of service data within the DTV Closed-Caption Channel. Caption providers and encoding equipment algorithms govern the frequency, priority, and bandwidth consumption for each individual service by these service blocks, as needed.

A Caption Channel Service Block consists of a Service Block Header followed by from 1 to 31 bytes of service data. See Figure 5. As described in 6.2.1, a Service Block Header may consist of 1 or 2 bytes.

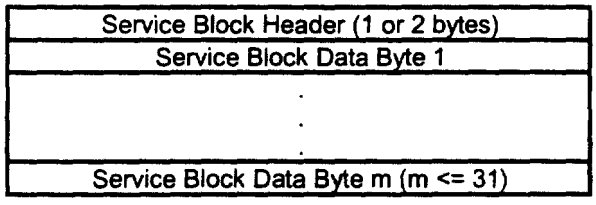

Figure 5 Service Block

NOTE--A Service Block cannot span a Caption Channel Packet. Service Blocks must begin and end within the same Caption Channel Packet.

The syntax for the Service Block is shown in Figure 6.

```
service_block {
        /* service block header */
        block_size          : 5 bits   /*    >= 0 && <= 31        */
        service_number      : 3 bits

        /* extended service block header extension */
        if (service_number == b'111' && block_size != 0)
        {
                extended_service_number : 6 bits
                null_fill               : 2 bits
        }

        /* block data sequence */
        if (service_number != 0)
        {
                for (i = 0; i < block_size; i++)
                {
                        Block_data[i]     : 8 bits
                }
        }
}
```

Figure 6 Service Block Syntax

6.2.1 Standard Service Block Header

The one-byte Standard Service Block Header consists of 2 parts: the Service Number (sn), and the Service Block Size (bs). See Figure 7. The Service Number (sn_0 - sn_2) is defined in the 3 high-order bits of the block header byte, and the Block Size (bs_0 - bs_4) is defined in the 5 low-order bits of the block header byte.

"Standard" service numbers range from 1 to 6 (service #0 is reserved), with Service #1 being reserved for the Primary Caption Service, and Service #2 reserved for the Secondary Language Service. A service number value of 7 in bits sn_0 - sn_2 indicates an "Extended" Service Block (Section 6.2.2).

The service Block Size value ranges from 1 to 31 and indicates the number of bytes following the header. A Standard Service Block Size of 0 is meaningless.

b_7	b_6	b_5	b_4	b_3	b_2	b_1	b_0
sn_2	sn_1	sn_0	bs_4	bs_3	bs_2	bs_1	bs_0

Figure 7 Standard Service Block Header

6.2.2 Extended Service Block Header

In the event that a Caption Channel requires more than 6 simultaneous services, a 2-byte Extended Service Block Header is used. See Figure 8. The first byte of this extended header has the same format as the Standard Service Block Header with the exception that the high order 3 bits are fixed to a value of all 1's. This standard service number value of "7" identifies the Extended Service Block and indicates that the 2nd byte of the header contains an extended service number (sn_0 - sn_5) whose value may range from 7 to 63. Extended service numbers less than 7 are illegal (since they can already be specified with the Standard Service Block Header).

The Block Size (bs_0 - bs_4) value in the lower 5 bits of the first byte of the Extended Service Block Header is the number of bytes following the Extended Service Block Header.

b_7	b_6	b_5	b_4	b_3	b_2	b_1	b_0
1	1	1	bs_4	bs_3	bs_2	bs_1	bs_0
0	0	sn_5	sn_4	sn_3	sn_2	sn_1	sn_0

Figure 8 Extended Service Block Header

6.2.3 Null Service Block Header

A Null Service Block Header must be inserted as the last Service Block in the Caption Channel Packet, space permitting. This header type indicates that there are no more Service Blocks in the packet for the DTVCC decoding hardware to process. See Figure 9. Encoding equipment should null fill (i.e., zero out) the Caption Channel Packet buffer before Service Blocks are inserted, thus insuring that a null header is always present in non-full Caption Channel Packets.

b_7	b_6	b_5	b_4	b_3	b_2	b_1	b_0
0	0	0	0	0	0	0	0

Figure 9 Null Service Block Header

6.2.4 Service Block Data

Up to 31 bytes of Service Data follow the Service Block Header within the Service Block. The contents of the data portion of the service block consists of caption data coding and interpretation (Sections 7 and 8). Service Block Data are separated from the Service Block and are routed to the appropriate service processors in the DTV receiver decoder. This separation process creates the individual byte streams for each of the services which are handed off to the DTVCC Coding Layer.

6.2.5 Service Blocks in Caption Channel Packet

Service Blocks are time division multiplexed and inserted sequentially in the Caption Channel Packet path (Section 4.5).

Service Blocks may not cross Caption Channel Packet boundaries; i.e., if a service requires more data than the current packet allows, then the service block is truncated to fit the current packet, and a new Service Block with a new Service Block Header and the remaining data bytes are placed at the start of, or elsewhere, within the next packet.

Figure 10 shows an example of a Caption Channel Data Packet with 3 Standard Service Blocks and 1 Extended Service Block. The Caption Channel Packet size is 20 bytes and the Packet Sequence Number is 2.

									Packet Byte
Pkt Size: 20/2, Seq# 2	1	0	0	0	1	0	1	0	0 (Packet Header)
SN: 1, BS: 3	0	0	1	0	0	0	1	1	1 (Service 1)
									2
									3
									4
SN: 6, BS: 4	1	1	0	0	0	1	0	0	5 (Service 6)
									6
									7
									8
									9
ESN: 21,	1	1	1	0	1	0	0	0	10 (Ext. Service 21)
BS: 8	0	0	0	1	0	1	0	1	11
									12
									13
									14
									15
									16
									17
									18
									19
Null Service Header	0	0	0	0	0	0	0	0	20

Figure 10 Service Blocks in Caption Channel Packets (Example)

7 DTVCC Coding Layer - Caption Data Services (Services 1 - 63)

The DTVCC Coding Layer describes how data are coded for the caption channel services. The Caption Data Coding Layer defines the assignment of numerical codes for code space control, caption commands, and caption characters and symbols.

7.1 Code Space Organization

Consistent with ANSI X3.41 and ISO 2022, the 256 position code space is divided into four code groups: the CL, GL, CR and GR. See Table 6 and Table 7. Each group contains a standard code set and an extended code set.

- The CL group contains the 32 addressable codes from 00h to 1Fh. The C0 (a subset of the ASCII, ANSI X3.4 Miscellaneous Control Codes) and C2 (Extended Miscellaneous Control Codes) code sets are mapped to this space.
- The GL group contains the 96 addressable codes from 20h to 7Fh. The G0 (a slightly modified version of the ANSI X3.4 ASCII Printable Character set) and G2 (Extended Control Code Set 1) code sets are mapped to this space.
- The CR group contains the 32 addressable codes from 80h to 9Fh. The C1 (Caption Control Codes) and C3 (Extended Control Code Set 2) code sets are mapped to this space.
- The GR group contains the 96 addressable codes from A0h to FFh. The G1 (ISO 8859-1 Latin 1 Characters) and G3 (future character and icon expansion) code sets are mapped to this space.

b3-b0 \ b7-b4:	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
0																
1																
2																
3																
4																
5																
6	**CL**		**GL**						**CR**		**GR**					
7	**(C0, C2)**		**(G0, G2)**						**(C1, C3)**		**(G1, G3)**					
8	**Set**		**Set**						**Set**		**Set**					
9																
A																
B																
C																
D																
E																
F																

Table 6 DTVCC Code Space Organization

	C 0		G 0						C 1		G 1					
b7-b4	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
b3-b0 0	NUL	EXT1	SP	0	@	P	`	p	CW0	SPA	NBS	°	À	Đ	à	ð
1			!	1	A	Q	a	q	CW1	SPC	¡	±	Á	Ñ	á	ñ
2			"	2	B	R	b	r	CW2	SPL	¢	²	Â	Ò	â	ò
3	ETX		#	3	C	S	c	s	CW3		£	³	Ã	Ó	ã	ó
4			$	4	D	T	d	t	CW4		¤	´	Ä	Ô	ä	ô
5			%	5	E	U	e	u	CW5		¥	µ	Å	Õ	å	õ
6			&	6	F	V	f	v	CW6		¦	¶	Æ	Ö	æ	ö
7			'	7	G	W	g	w	CW7	SWA	§	·	Ç	×	ç	÷
8	BS	P16	(	8	H	X	h	x	CLW	DF0	¨	¸	È	Ø	è	ø
9			)	9	I	Y	i	y	DSW	DF1	©	¹	É	Ù	é	ù
A			*	:	J	Z	j	z	HDW	DF2	ª	º	Ê	Ú	ê	ú
B			+	;	K	[	k	{	TGW	DF3	«	»	Ë	Û	ë	û
C	FF		,	<	L	\	l	|	DLW	DF4	¬	¼	Ì	Ü	ì	ü
D	CR		-	=	M	]	m	}	DLY	DF5		½	Í	Ý	í	ý
E	HCR		.	>	N	^	n	~	DLC	DF6	®	¾	Î	Þ	î	þ
F			/	?	O	_	o	♪	RST	DF7	¯	¿	Ï	ß	ï	ÿ
0			TSP	▮							CC					
1			NBTSP	‘												
2				’												
3				“												
4				”												
5			…	•												
6								1/8								
7								3/8								
8								5/8								
9				™				7/8								
A			Š	š				▕								
B																
C			Œ	œ				▁								
D				℠				—								
E																
F				Ÿ				▛								
	C 2		G 2						C 3		G 3					

Table 7 DTVCC Code Set Mapping

NOTE--This section lists all required and optional caption codes. Refer to Section 9.4 for a list of required codes for a minimum DTVCC receiver implementation.

7.2 Extending the Code Space

The characters in the extended code sets of the CL, CR, GL, and GR code groups are accessed using the **EXT1** code (10h) in the C0 code set (Miscellaneous Control Codes). Normally (i.e., without extending the code space) the base codes in the four code groups (CL, GL, CR, and GR) represent the characters, control codes, and commands in the C0, C1, G0, and G1 code sets. By prefixing the codes in the code groups with the **EXT1** code (and thus forming the start of a two-byte code), the symbols in the extended C2, C3, G2, and G3 code sets are referenced: that is, each character in these code sets require the transmission of two codes (i.e., **EXT1** plus a base code) in order to be referenced. **EXT1** must start every 2-byte extended code sequence.

When **EXT1** is not encountered, then reference to the base code sets (C0, C1, G0, and G1) is assumed. That is, **EXT1** is only active for the two-byte extended code sequence in which it exists.

For example, to generate the closed-caption symbol (CC) in the G3 code set, the following sequence must be specified: 10h, A0h (**EXT1**, **NBS**).

The code space may be extended further (for future use) to handle other character sets not included in the language sets listed in section 7.4.4. This extension capability anticipates code sets which require 16-bit character code addressing, such as characters to implement Chinese and Japanese. The **P16** code in the C0 Miscellaneous Control Code set is used for this purpose. When a decoder encounters the **P16** code, it uses the succeeding two bytes to address characters in a 16-bit code set.

7.3 Unused Codes

Any codes not specified in the following sections are reserved for future standardization. Decoders encountering any undefined codes should adhere to the size (e.g., 1 byte, 2 byte, 3 byte and variable length) characteristics of these codes, as indicated in the following sections. This assures that future extensions to the coding scheme can be ignored by decoders which do not support them.

7.4 Numerical Organization of Codes

The following subsections detail the mapping of the individual code sets (C0, C1, C2, C3, G0, G1, G2, and G3) of the DTVCC code space.

7.4.1 C0 Code Set - Miscellaneous Control Codes

The C0 code set contains the 32 addressable codes from 00h to 1Fh. See Table 8.

Codes 00h through 0Fh are single byte codes.
Codes 10h through 17h are two byte codes.
Codes 18h through 1Fh are three byte codes.

The **NUL**, **BS**, **FF**, and **CR** codes are preserved from the standard ASCII control code set. The **ETX** code is also from the ASCII control code set, but it has a specical use in that it is required at the end of a caption text segment to terminate the segment when the segment is not immediately followed by another caption command (see Section 8.10.4). The **EXT1** code is used to extend the DTVCC code space (see Section 7.2). The **P16** code is used as a further code space extension for 16-bit character sets.

b3-b0 \ b7-b4	C 0	
	0	1
0	NUL	EXT1
1		
2		
3	ETX	
4		
5		
6		
7		
8	BS	P16
9		
A		
B		
C	FF	
D	CR	
E	HCR	
F		

Table 8 C0 Code Set

7.4.2 C1 Code Set - Captioning Command Control Codes

The C1 code set contains the 32 addressable codes from 80 to 9F. See Table 9. This set contains the captioning command control codes (window creation commands, character attributes, etc.). The use of these codes and the DTVCC captioning commands are detailed in Section 8.10.

b3-b0 \ b7-b4	C 1	
	8	9
0	CW0	SPA
1	CW1	SPC
2	CW2	SPL
3	CW3	
4	CW4	
5	CW5	
6	CW6	
7	CW7	SWA
8	CLW	DF0
9	DSW	DF1
A	HDW	DF2
B	TGW	DF3
C	DLW	DF4
D	DLY	DF5
E	DLC	DF6
F	RST	DF7

Table 9 C1 Code Set

7.4.3 G0 Code Set - ASCII Printable Characters

The G0 code set contains the 96 addressable codes from 20h to 7Fh. See Table 10. This set provides the ANSI X3.4 ASCII printable characters with the substitution of the music note character for the ASCII **DEL** character.

		G 0				
b7-b4	2	3	4	5	6	7
b3-b0						
0	SP	0	@	P	`	p
1	!	1	A	Q	a	q
2	"	2	B	R	b	r
3	#	3	C	S	c	s
4	$	4	D	T	d	t
5	%	5	E	U	e	u
6	&	6	F	V	f	v
7	'	7	G	W	g	w
8	(	8	H	X	h	x
9	)	9	I	Y	i	y
A	*	:	J	Z	j	z
B	+	;	K	[	k	{
C	,	<	L	\	l	|
D	-	=	M	]	m	}
E	.	>	N	^	n	~
F	/	?	O	_	o	♪

Table 10 G0 Code Set

7.4.4 G1 Code Set - ISO 8859-1 LATIN-1 Character Set

The G1 code space contains the 96 addressable codes from A0h to FFh. See Table 11. This set consists of the ISO 8859-1 Latin-1 character set, also known as the Windows/ANSI character set. This set, when used in conjunction with the ASCII set, provides all the characters needed to encode text in Danish, Dutch, Faeroese, Finnish, French, German, Icelandic, Irish, Italian, Norwegian, Portuguese, Spanish and Swedish. Many other languages can be written with this set of letters, including Hawaiian, Indonesian/Malay, and Swahili. ISO 8859-1 also extends the ASCII set with additional miscellaneous punctuation and mathematical signs.

Code **NBS** (A0h) represents a non-breaking space. This code is to be used (instead of a space character) between words that should not be split when word-wrapping is in effect.

		G 1				
b3-b0 \ b7-b4	A	B	C	D	E	F
0	NBS	°	À	Ð	à	ð
1	¡	±	Á	Ñ	á	ñ
2	¢	²	Â	Ò	â	ò
3	£	³	Ã	Ó	ã	ó
4	¤	´	Ä	Ô	ä	ô
5	¥	µ	Å	Õ	å	õ
6	¦	¶	Æ	Ö	æ	ö
7	§	·	Ç	×	ç	÷
8	¨	¸	È	Ø	è	ø
9	©	¹	É	Ù	é	ù
A	ª	º	Ê	Ú	ê	ú
B	«	»	Ë	Û	ë	û
C	¬	¼	Ì	Ü	ì	ü
D	-	½	Í	Ý	í	ý
E	®	¾	Î	Þ	î	þ
F	¯	¿	Ï	ß	ï	ÿ

Table 11 G1 Code Set

7.4.5 G2 Code Set - Extended Miscellaneous Characters

The G2 code set contains the extended miscellaneous characters. See Table 12. Characters in the G2 space are transmitted by preceding them with the control character **EXT1** (10h) from the C0 character set. Following the **EXT1** extender prefix, the G2 characters are addressed with the base in the range 20h - 7Fh.

The unshaded characters in the G2 table below are those which exist in the Microsoft Windows character map. They are positioned in this code set to reflect their relative positioning in the MS Windows map. In Windows, these characters are mapped to the code set in the range 80h to 9Fh.

The **TSP** character (20h) represents a transparent space. This character has no text foreground or background color; i.e., it passes through the fill color of the window containing it.

The **NBTSP** character (21h) represents a non-breaking transparent space. This character is the same as a transparent space (TSP) with the exception that it should be used between words that should not be split when word-wrapping is in affect.

The ▮ character (30h) is a solid block which fills the entire character position with the text foreground color.

Also included in this set are the block drawing characters, opening and closing single and double quote marks, the trade mark symbol, the service mark symbol, and the remaining Latin-1 characters.

		G 2					
	b7-b4	2	3	4	5	6	7
b3-b0	0	TSP	▮				
	1	NBTSP	‘				
	2		’				
	3		“				
	4		”				
	5	…	•				
	6						1/8
	7						3/8
	8						5/8
	9		™				7/8
	A	Š	š				▕
	B						▗
	C	Œ	œ				▖
	D		℠				—
	E						
	F		Ÿ				▛

Table 12 G2 Code Set

7.4.6 G3 Code Set - Future Expansion

The G3 code set is reserved for future expansion. It currently contains the single caption icon [CC]. See Table 13.

Characters in the G3 space are transmitted by preceding them with the control character **EXT1** (10h) from the C0 code set. Following the **EXT1** extender prefix, the G3 characters are addressed with the base codes in the range A0h - FFh.

		G 3					
	b7-b4	A	B	C	D	E	F
b3-b0	0	[CC]					
	1						
	2						
	3						
	4						
	5						
	6						
	7						
	8						
	9						
	A						
	B						
	C						
	D						
	E						
	F						

Table 13 G3 Code Set

7.4.7 C2 Code Set - Extended Control Code Set 1

The C2 code set is reserved for future extended miscellaneous control and caption command codes. See Table 14. Codes in the C2 space are transmitted by preceding them with the control character **EXT1** (10h) from the C0 code set. Following the **EXT1** extender prefix, the C2 characters are addressed with the base codes in the range 00h - 1Fh.

These codes can be succeeded by additional data bytes per the following:

Codes 00h through 07h are single-byte control codes (0 - additional bytes).
Codes 08h through 0Fh are two-byte control codes (1 - additional byte).
Codes 10h through 17h are three-byte control codes (2 - additional bytes).
Codes 18h through 1Fh are four-byte control codes (3 - additional bytes).

Example: The total sequence for a four-byte control code would be:
EXT1, 18h, <data1>, <data2>, <data3>

DTVCC decoders which do not implement these commands must use their implied sizes to skip over them in the Service Blocks.

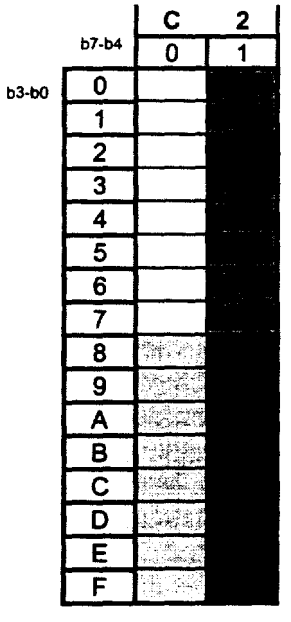

Table 14 C2 Code Set

7.4.8 C3 Code Set - Extended Control Code Set 2

The C3 code set is an additional set reserved for future extended miscellaneous control and caption command codes. See Table 15. Codes in the C3 space are transmitted by preceding them with the control character **EXT1** (10h) from the C0 character set. Following the **EXT1** extender prefix, the C3 command codes are addressed with the base codes in the range 80h - 9Fh.

Codes 80h through 8Fh are reserved for fixed-sized commands. These codes can be succeeded by additional data bytes per the following:

Codes 80h through 87h are five-byte control codes (4 - additional bytes).
Codes 88h through 8Fh are six-byte control codes (5 - additional bytes)

Example: The total sequence for a six-byte control code would be:
EXT1, 88h, <data1>, <data2>, <data3>,<data4>,<data5>

DTVCC decoders which do not implement these commands must use their implied sizes to skip over them in the Service Blocks.

Codes 90 through 9Fh are reserved for variable length caption commands. Variable-length caption commands have a 1-byte header following the command code. This header contains a 2-bit Type field (b7 - b6) and a 6-bit Length field (b5 - b0). The Type field allows a command to be broken up into several segments in order to be transmitted across multiple Service Blocks. The Type field has the following possible values: 00 - Beginning of Command (BOC), 01 - Continuation of Command (COC), 11 - End of Command (EOC), and All of Command (AOC). The Length field ranges from 0 - 63 and indicates the number of data bytes following the header. Data bytes can have any 8-bit value. Only one variable-length caption command per service can be transmitted at a time, and the command segments must be transmitted in order. This variable-length command capability is intended for commands which require the downloading of large units of data (e.g., fonts and graphics). DTVCC decoders which do not implement these commands must use the Length field to skip over them in the Service Blocks.

b3-b0 \ b7-b4	C	3
	8	9
0		
1		
2		
3		
4		
5		
6		
7		
8		
9		
A		
B		
C		
D		
E		
F		

Table 15 C3 Code Set